DEC STD 067-2 Packaging of Electrostatic Discharge-Sensitive Devices: Procedures and Protective Packaging Materials

DOCUMENT IDENTIFIER: A-DS-EL00067-02-0000 Rev A, 21-Dec-1990

ABSTRACT: This standard specifies the proper method for packaging and handling ESD-sensitive devices during shipping and storage. Packaging and handling methods of non ESD-sensitive materials used in the ESD-controlled work area are also referenced.

APPLICABILITY: This standard applies to all ESD-sensitive devices, whether handled individually or in nonelectrostatic shielded assemblies, as well as all nonsensitive devices being used in the ESD free work area during receiving, packaging, and shipping. It pertains equally to manual and automatic operations. This standard applies to all personnel who handle, package of ship static-sensitive parts or assemblies or work in an ESD free area.

STATUS: APPROVED 21-Dec-1990; use VTX SMC for current status.

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1 INTRODUCTION

Static electricity has been found to damage electronic devices in all forms, from individual integrated circuits (ICs) to subassemblies, assemblies, and modules to finished systems. Safeguards are established for the protection of these devices during test and assembly; this standard deals with protective packaging methods to be used in the storage, handling, and transportation of these devices.

Static electricity can be caused by the rubbing together or separating of two materials. This action is called triboelectric generation and it causes a static voltage on each of these two materials. The highest static voltage producers are materials with insulative properties; when two insulative materials are rubbed together or separated, voltages as high as 38,000 V can be generated. When the charged material comes in contact with an uncharged material, an electrostatic discharge (ESD) occurs.

Most electronic devices are sensitive to ESD to some degree. Components most susceptible are metal oxide semiconductors (MOS), Schottky and low power Schottky devices, film resistors, and linear devices that use MOS capacitors. To protect these and other ESD-sensitive devices during the operations of handling, transportation and storage, ESD protective packaging has been developed.

ESD protective packaging is any material that is capable of:

1. preventing the generation of static electricity.
2. dissipating electrostatic charges over its surface or volume.
3. providing shielding from ESD or electrostatic fields.

1.1 PURPOSE

This document establishes the guidelines for packaging designed to protect ESD-sensitive devices from the effects of ESD. It describes the available packaging materials, their characteristic electrical properties, and their proper applications.

1.2 SCOPE

This standard applies to the packaging of all ESD-sensitive devices, whether handled individually or in nonelectrostatic shielded assemblies, as well as the packaging of all nonsensitive devices used in an ESD-controlled work area. It pertains equally to manual and automatic operations.

1.3 RESPONSIBILITIES

Packaging and packing area supervisors and their management are responsible for ensuring that the requirements of this standard are enforced. If the packaging and packing is accomplished in an ESD-controlled work area, the supervisor is responsible for ensuring conformance to this standard. Personnel who handle and package ESD devices must be grounded and wear ESD protective clothing. Refer to *DEC STD 067-3 Handling of Electrostatic Discharge-Sensitive Devices: Manufacturing Facilities* and *DEC STD 067-4 Handling of Electrostatic Discharge-Sensitive Devices: In Customer Service Areas* for more information about manufacturing and customer service areas.

2 ESD PROTECTIVE PACKAGING MATERIALS

ESD protective packaging materials are classified in five groups.

1. Conductive
2. Static dissipative
3. Insulative
4. Static shielding
5. Antistatic

Conductive, static dissipative, and insulative materials rely on the property of surface resistivity (ohms per square) or volume resistivity (ohms - cm). Static-shielding materials and antistatic materials rely on other properties, such as the ability to shield a device from electric fields, or the propensity to not cause electrostatic charging.

ESD protective packaging materials are defined by characteristic response to a variety of tests: surface and volume resistivity, charge retention or static decay, triboelectric generation, field attenuation, and direct discharge.

- Resistivity demonstrates the characteristic resistance across a square or cubic unit of the material.
- Charge retention or static decay tests demonstrate the material's ability to discharge an electrostatic charge. The charge retention test determines if there is a complete path that allows stored static energy to be drained from the material. Charge retention is caused when a conductive layer is charged through induction and capacitive coupling, and when an insulation layer prevents the charge from draining to a grounded surface.
- Triboelectric generation is a phenomenon where, when two materials are rubbed or separated, an equal but opposite charge is developed on each of the two materials. Triboelectric generation is the source of virtually all static electricity. Most insulating plastics are prone to triboelectric generation while conductive materials are not prone. When a material is tested to be not prone to triboelectric generation, it is said to be antistatic.
- Field attenuation testing demonstrates a material's ability to block an electrostatic field.
- Direct discharge testing demonstrates a material's ability to protect an ESD-sensitive device from the direct application of an electrostatic discharge.

There are a variety of other tests that materials are subjected to, as required by the purchase specification and the end usage of the material. These tests include mechanical tests such as puncture or crinkle tests, and chemical tests such as out-gassing and corrosion tests.

The electrostatic protective properties of a material are defined by that material's electrical properties. Electrical tests should be repeated after mechanical tests to guarantee the material's functionality. Refer to section 3.1.1 for the test cycle.

NOTE

No material shall have free amines or other chemicals that will adversely affect computer parts. The materials shall not cause corrosion when tested in accordance

with Federal Test Method Standard (FTMS), Method 3005, using test panels with chromate, blue brite, solder, aluminum, and gold surfaces.

In general, the first layer of protective material used in packaging is static dissipative. Such a layer may be in the form of a homogeneous single film or cushion, or a multilayered structure used as either a flat film or a cushion pad as in a pouch configuration. When conductive containers are used, the conductive layer must not come in contact with the ESD-sensitive item.

2.1 CONDUCTIVE MATERIALS

Conductive materials are either surface conductive or volume conductive. These two properties are not necessarily interrelated. Conductive materials typically fall into one of three categories: metal, a material impregnated with metal, carbon particles or other conductive materials, or surface treated with materials through a process of lacquering, plating, metallizing, or printing.

Conductive materials are used to provide static shielding; they are not necessarily antistatic. A surface conductive material has a surface resistivity of less than 1e+5 ohms/square. A volume conductive material has a volume resistivity of less than 1e+4 ohm-cm. Conductive materials are required to decay an electrostatic charge to 1% of the original charge in less than 2 seconds. Conductive materials shall not cause triboelectric generation at an electrostatic voltage of greater than 200 V (positive or negative).

2.2 ELECTROSTATIC SHIELDING MATERIALS

Electrostatic shielding packaging is designed to attenuate an electrostatic field so that its effects do not reach the packaged items. It is designed to provide a Faraday cage around the ESD-sensitive device.

Electrostatic shielding materials are either a homogeneous conductive material or a multilayer material with at least one conductive layer. Multilayer bag materials, used by Digital, must have at least one buried metal layer sandwiched between outer layers of static dissipative film. The buried conductive layer must have a surface resistivity of less than 1e+4 ohms/square, or a volume resistivity of less than 1e+3 ohms-cm.

NOTE

Environmental concerns are limiting the use of multilayer materials such as metallized layer bags, in some areas. Where economically feasible, use containers that are reusable and/or materials that are recyclable.

Testing of electrostatic shielding materials must include field attenuation and direct discharge tests. The material must demonstrate that when approached or contacted by an electrostatic field or voltage, the devices being protected by the shielding material will not be damaged. Electrostatic shielding materials must not cause triboelectric generation of greater than 200 V (positive or negative); must be able to decay an electrostatic discharge voltage to 1% of that voltage in less than 2 seconds; and must have a surface resistivity in the static dissipative range on all surfaces.

2.3 STATIC DISSIPATIVE MATERIALS

Static dissipative material has a surface resistivity equal to or greater than 1e+5 ohms/square but less than 1e+12 ohms/square and/or a volume resistivity equal to or greater than 1e+4 ohm-cm but less than 1e+11 ohm-cm. Static dissipative materials are required to decay an electrostatic discharge voltage to 1% of that voltage in less than 2 seconds (typical test voltage is 5 kV to less than 50 volts). Static dissipative materials shall not cause triboelectric generation of an electrostatic voltage greater than 200 V (positive or negative).

2.4 INSULATIVE MATERIALS

Insulative material has a surface resistivity equal to or greater than 1e+12 ohms/square or a volume resistivity equal to or greater than 1e+11 ohm-cm. The insulative materials used in packaging shall not cause triboelectric generation of an electrostatic voltage greater than 200 V (positive or negative).

NOTE

If it is necessary to use insulative packaging materials, it is recommended that the lowest possible resistivity be used. A lower resistivity will minimize triboelectric generation and decay static charges that do occur on the material.

2.5 ANTISTATIC MATERIALS

Antistatic material resists triboelectric charge generation and does not have a resistivity range. Digital, in agreement with the Electronic Industrial Association (EIA) and the EOS/ESD Association, defines antistatic materials solely in terms of their propensity to not triboelectrically generate ESD voltages.

NOTE

Antistatic materials have a resistivity but the value is not significant since triboelectric charging is not dependent on the resistivity.

Antistatic materials shall not cause triboelectric generation of an electrostatic voltage greater than 200 V (positive or negative).

3 PACKAGING CLASSIFICATION

ESD-sensitive items shall be packaged in accordance with their level of sensitivity. ESD-sensitivity levels are determined using the test procedure described in *DEC STD 067-0 Handling of Electrostatic Discharge-Sensitive Devices: Procedures and Protective Materials*. This test procedure is from the EOS/ESD Association's EOS/ESD S5, *Human Body Model (HBM) Electrostatic Discharge Sensitivity Testing, 1988*. This test is a modification of MIL STD 883C. The ESD-sensitivity test is applicable to all ESD electronic devices. The type of packaging required for each sensitivity class is as follows.

CLASS 1—ESD Sensitivity 0 to 1999 Volts
Class 1 ESD-sensitive devices shall be packaged using a completely enclosed electrostatic shielding container. This container may be surface or volume-conductive, or a multilayer material. A reusable conductive container with a static-dissipative liner or insert, keeping the ESD-sensitive device from coming in contact with the conductive outer container, is recommended.

CLASS 2—ESD Sensitivity 2000 - 3999 Volts
Class 2 ESD-sensitive devices shall be packaged using a volume or surface-resistive static dissipative container.

CLASS 3—ESD Sensitivity 4000 to 15999 Volts
Class 3 ESD-sensitive devices shall be packaged using antistatic materials.

NOTE

Devices not sensitive to ESD damage below 16,000 V are classified non ESD-sensitive, and do not require ESD protective packaging. Often, however, these products are packaged in antistatic materials to prevent damage to other devices that may be sensitive to ESD in the area.

3.1 QUALIFICATION OF PACKAGING MATERIALS

Qualification of ESD protective packaging materials must be in accordance with packaging specifications as written. Most specifications for ESD protective materials packaging are Class 99. Testing of ESD protective packaging can be done by EOS/ESD Control Engineering or by any other Industrial Packaging Engineering (IPE) recommended laboratory.

3.1.1 Test Cycle for Qualification of ESD Protective Packaging

The test cycle for qualification of ESD protective packaging is as follows.

1. Electrical tests are done on the material samples as delivered from the manufacturer or distributor.
2. The material samples are divided into three groups.
   - — One group is stressed with mechanical tests such as puncture test or rub test.
   - — One group is stressed with three environmental conditions:
     - The 12 day heat cycle in accordance with FTMS 101C Method 4046.1.
     - A control sample at ambient conditions of 23°C ± 3°C and 50% ± 2% relative humidity (RH).
     - Either a high temperature and high humidity cycle as described in *DEC STD 102-0 Environmental Standard for Computers and Peripherals - General Test Requirements* or the Rain Test in accordance with FTMS 101C Method 4046.1.
   - — One group is stressed with chemical tests such as out-gassing and corrosion tests.
3. Electrical tests are performed on the material samples once they have completed the above tests.
4. All samples are put into a dry chamber at ambient temperature and less than 15% RH for 48 hours.
5. Electrical tests are performed, for the third time, on the material samples.

The material samples shall pass all testing as described in this standard, the product specifications, or as required by IPE.

4 PROTECTIVE PACKAGING MARKING

Packages which form a Faraday cage must have a tamper evident method of securing the closure.

The ESD-sensitive symbol as described in A-PS-900045-GS *Packaging Products for International Shipments - Introduction* shall be displayed on the outer surface of ESD protective packaging. Closure for flexible conductive enclosures, for example bags, shall be secured with a pressure sensitive label as defined in A-PS-3622555 *Label*. When bags are heat sealed, the ESD-sensitive label information may be preprinted on the bag.

NOTE

Only ESD-sensitive materials shall be marked with ESD-sensitive markings.

APPENDIX A REFERENCED DOCUMENTS

A.1 EL-Class Digital Documents

EL-Class Number	Document Title
EL-00067-00	*DEC STD 067-0 Electrostatic Discharge - Sensitive Devices*
EL-00067-01	*DEC STD 067-1 Electrostatic Discharge-Sensitive Devices: In Engineering Facilities*
EL-00067-03	*DEC STD 067-3 Handling of Electrostatic Sensitive Devices: Manufacturing Facilities*
EL-00067-04	*DEC STD 067-4 Handling of Electrostatic Discharge (ESD) -Sensitive Material in all Customer Services Operations and Logistics Areas*
EL-00102-00	*DEC STD 102-0 Environmental Standard for Computers and Peripherals - General Test Requirements*

Use VTX SMC to order copies of EL-class documents from Standards and Methods Control. Send distribution questions to JOKUR::SMC or call DTN: 234-4423.

A.2 Other Digital Documents

Document Number	Document Title
A-PS-9900045-GS	*Packaging Products for International Shipments - Introduction*

A.3 Other Documents

Document Number	Document Title
A-PS-3622555	*Label*
EOS/ESD S5	*Human Body Model (HBM) Electrostatic Discharge Sensitivity Testing, 1988*
FIMS 101C 4046.1	*Electrostatic Properties of Materials, 8 October 1982*
MIL-STD-883C 3015.6	*ESD Sensitivity Classification, 12 February 1988*

Copies of A-PS documents (Digital Purchase Specifications) may be obtained from Reprographics, MLO4-1/E27, DTN: 223-2323, ECAD::REPRO

A.4 Ordering Information

Following are the sources for documents not available from Standards and Methods Control.

- EOS/ESD Association, Inc.
  Norstar Building,
  200 Liberty Plaza,
  Rome, NY 13440
- Naval Publication and Forms Center
  5801 Tabor Avenue
  Philadephia, PA 19120

APPENDIX B RELATED DOCUMENTS

B.1 EL-Class Digital Documents

EL-Class Number	Document Title
EL-00045-00	*DEC STD 045-0 Packaging Products for International Shipment - Introduction*
EL-00178-01	*DEC STD 178-1 Digital Marking Requirements for Piece Parts*
EL-00178-04	*DEC STD 178-4 Shipping Container Marking Requirements for Finished Goods*

Use VTX SMC to order copies of EL-class documents from Standards and Methods Control. Send distribution questions to JOKUR::SMC or call DTN: 234-4423.

B.2 Other Documents

Document Number	Document Title
ASTM D257-78	*DE Resistance of Insulating Materials, 1983.*
EIA 541	*Packaging Material Standard for ESD Sensitive Items, V. 8 August 1988*
MIL-STD-883C 3015.6	*ESD Sensitivity Classification, 12 February 1988.*

B.3 Ordering Information

Following are the sources for documents not available from Standards and Methods Control.

- American Society for Testing and Materials (ASTM)
  1916 Race Street
  Philadelphia, PA 19103
- Electronic Industries Association
  Engineering Department
  2001 Pennsylvania Avenue N.E.
  Washington, D.C. 20006

GLOSSARY

antistatic agent: A chemical compound which, when impregnated or formulated into or topically applied to a primary material or substrate, gives the primary material antistatic properties.

antistatic property: The prevention of triboelectric charge generation by effectively minimizing the production of a static charge when materials are separated from another surface.

barrier materials: Materials used to shield ESD sensitive materials from damage by ESD.

blooming: Continuous migration of the antistatic agent to the surface of the material.

buried metal layer: A Faraday shielding metallic layer laminated between two static dissipative materials.

CMOS: Complementary Metal Oxide Semiconductor.

conductor: A material made of metal or impregnated with metal or carbon particles or other conductive materials, or whose surface has been treated with such materials through a process of lacquering, plating, metallizing, or printing. A conductive material for static control purposes shall have a surface resistivity less than 1e+5 ohms/square or 1e+4 ohm-cm if volume-conductive. A conductive material is not necessarily antistatic.

corrosivity: Characteristic property of a material that causes other materials to corrode.

electrical overstress (EOS): The electrical stressing of items beyond their electrical specifications. Includes ESD, voltage transients, and lightning.

electrically continuous surface: A surface that is electrically conductive in that current can be passed at an applied voltage between any two points on its physical surface.

electrostatic discharge (ESD): The transfer of electrical charge between bodies at different electrostatic potentials.

electrostatic discharge sensitivity (ESDS): A property of items in which they are inherently susceptible to either catastrophic failure or latent damage when exposed to sources of electrostatic discharge. Items are often categorized as to their levels of sensitivity, but all ESDS items require some means of ESD-protective packaging and handling.

electrostatic field: The region surrounding an electrically charged object in which another electrical charge will experience a force. Quantitatively, it is the voltage gradient between two points at different potentials.

engineering abbreviations:
n (nano), billionth or 1e-9
μ (micro), millionth or 1e-6
m (milli), thousandth or 1e-3
k (kilo), thousand or 1e+3
M (mega), million or 1e+6
G (giga), billion or 1e+9

ESD protective: A property of materials capable of one or more of the following:
a. preventing the generation of static electricity
b. dissipating electrostatic charges over its surface or volume
c. providing shielding from ESD or electrostatic fields

Faraday shield or cage: Also called Faraday screen, a network of parallel wires connected to a common conductor at one end to provide electrical shielding. The common conductor is usually grounded.

humidity-dependent: A material that is dependent on the ambient relative humidity to maintain its ESD protective properties.

insulator, electric: A material with a surface resistivity equal to or greater than 1e+12 ohm/square or a volume resistance equal to or greater than 1e+11 ohm-cm.

intimate packaging material: Those materials that are in direct contact with the packaged device.

latent failure: A hidden failure that did not result in an immediately detectable defect condition.

non-intimate packaging: Those materials that do not come in direct contact with the device or assembly being packaged, or are outside of the intimate packaging material.

out-gassing: Release of a gaseous material from the surface of a material due to environmental conditions.

packaging: The technique of preparing goods for distribution; the design criteria, processes, and procedures used to protect material from deterioration and damage from the time manufacuring is completed until ultimate use or disposal; the processes and procedures used to protect an item in a unit package.

packing: The selection or construction of the shipping container and assembling of items or packages therein, including any padding, bracing, or markings for identification of contents.

resistivity, volume: The ratio of the dc voltage per unit thickness applied across two electrodes in contact with a specimen to the amount of current per unit area passing through the system. Volume resistivity is generally given in ohm-centimeters.

resistivity, surface: The ratio of dc voltage to the current that passes across the surface of the system. Surface resistivity is the resistance between two opposite sides of a square and is independent of the size of the square. Surface resistivity is expressed in ohms/square.

Schottky diode: A fast switching diode made by a metal process, with a forward voltage drop of 0.2 to 0.5 volt.

shield, electromagnetic: A screen or other housing placed around devices or circuits to reduce the effects of magnetic fields. See Faraday shield.

shield, electrostatic: A barrier or enclosure that prevents the penetration of an electrostatic field. An electrostatic shield may not offer much protection against electromagnetic fields. See Faraday shield.

static-dissipative: A property of a material having a surface resistivity equal to or greater than 1e+5 ohms/square but less than 1e+12 ohms/square or a volume resistivity equal to or greater than 1e+4 ohm-cm but less than 1e+11 ohm-cm.

triboelectric generation: The generation of electrostatic charges when two pieces of material in intimate contact are separated. Substantial generation of static electricity can be caused by contact and separation of two materials or by rubbing two substances together. (See also triboelectric series.)

triboelectric series: A list of substances arranged so that one substance becomes positively charged when separated from one substance farther down the list, or negatively charged when separated from one farther up the list. The series' main utility is to indicate likely resultant charge polarities after triboelectric generation. However, this series is derived from specially prepared and cleaned materials tested in very controlled conditions. In everyday circumstances, materials respond reasonably close to what the series predicts and the series can produce charge polarities opposite to that expected. Thus, the series should be used only as a guide. Refer to DEC STD 067-01 for a more complete discussion of the triboelectric series.

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